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Ms. Magalie Roman Salas, Esq.
 Secretary
 Federal Communications Commission
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 The Portals
 445 Twelfth Street, SW
 Washington, D.C. 20554

In the Matter of)	
)	
Reallocation of the 216-220 MHz,)	ET Docket No. 00-221
1390-1395 MHz, 1427-1429 MHz,)	RM-9267
1429-1432 MHz, 1432-1435 MHz,)	RM-9692
1670-1675 MHz, and 2385-2390 MHz)	RM-9797
Government Transfer Bands)	RM-9854

Dear Ms. Salas:

Transmitted herewith by the National Academy of Sciences, through the Committee on Radio Frequencies of the National Research Council, are an original and five copies of its Comments in the above-referenced proceedings.

If additional information is required concerning this matter, please communicate with this office.

Sincerely yours,



Joel Parriott
 Program Officer

cc: Members of CORF

Mr. Paul J. Feldman, Esq., Fletcher, Heald & Hildreth
 Dr. Tomas Gergely, National Science Foundation
 Dr. Charles Wende, National Aeronautics and Space Administration
 Dr. Donald C. Shapero, National Research Council

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COMMENTS OF THE
NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

The National Academy of Sciences, through the National Research Council's Committee on Radio Frequencies¹ (hereinafter, "CORF"), hereby submits its Comments in response to the Federal Communications Commission's November 20, 2000, Notice of Proposed Rulemaking in the above-captioned docket ("NPRM"). In these Comments, CORF strongly opposes the 1.4 GHz Band Plan Option 3 because both experience and calculations indicate that the allocations proposed therein will be harmful to users of the Earth-Exploration Satellite Service ("EESS") and Radio Astronomy Service ("RAS") who make observations in the 1.4 GHz band. In addition, CORF does not oppose the allocation of the 1670-1675 MHz band to Fixed and Mobile Services (except aeronautical mobile), as long as service rules are enacted that protect important RAS observations in the adjacent 1660-1670 MHz band.

I. Introduction: The Importance of RAS and EESS
Observations in the 1.4 GHz and 1.6 GHz Bands, and the
Unique Vulnerability of Passive Services to Out-of-Band
and Spurious Emissions

CORF has a substantial interest in this proceeding because it represents the interests of the scientific users of the radio spectrum, including users of the RAS and EESS bands. Both RAS and EESS observers perform extremely important yet vulnerable research.

¹ The CORF membership is listed in the attachment.

As the Commission has long recognized, radio astronomy is a vitally important tool used by scientists to study our universe. Through the use of radio astronomy, scientists have in recent years made the first discovery of planets outside the solar system, circling a distant pulsar. Measurements of radio spectral line emission have identified and characterized the birth sites of stars in our own galaxy and the complex distribution and evolution of galaxies in the universe. Radio astronomy measurements of the cosmic microwave background have discovered ripples, generated in the early universe, which later formed the stars and galaxies we see today. Observations of supernovas have witnessed the creation and distribution of heavy elements essential to the formation of planets like Earth and of life itself.

Likewise, the EESS represents both a critical and a unique resource for monitoring Earth's global atmospheric and surface state and has made vital contributions to the study of land resource management, hazard prediction, meteorology, ocean studies, atmospheric chemistry, and global change. Currently, instruments operating in the EESS bands provide regular and reliable quantitative atmospheric, oceanic, and land measurements to support an extensive variety of scientific, commercial, and government (civil and military) data users. Applications of the data include aviation forecasts; flooding, hurricane, and severe storm warning and tracking; seasonal and interannual climate forecasts; decade-scale monitoring of climate variability; medium-range forecasting; studies of the ocean surface and internal structure; and many others.

These current benefits of this scientific research, obtained through years of work and substantial federal investment, as well as future benefits, must be protected.

As passive users of the spectrum, radio astronomers and Earth scientists have no control over the frequencies that they must use for their observations or over the character of the transmitted signal. These parameters are set by the laws of nature. Furthermore, the emissions that radio astronomers receive are extremely weak—a typical radio telescope receives only about one-trillionth of a watt from even the strongest cosmic source and routinely receives radiation from sources even one million times weaker than that. Because radio astronomy receivers are designed to pick up such remarkably weak signals, such facilities are therefore particularly vulnerable to interference from spurious and out-of-band emissions from licensed and unlicensed users of neighboring bands, and from those that produce harmonic emissions that fall into the RAS bands. The emissions received by passive EESS radiometers in Earth orbit are similarly weak. Changes in the emission by one hundredth of a trillionth of a watt can mean the difference between observing a dry, absorbent land surface as opposed to saturated soil with a high propensity for run-off and flooding during extreme precipitation events. This susceptibility to

interference is compounded by the fact that EESS sensors are pointed down toward Earth's surface and can easily experience harmful interference from out-of-band radiators.

Of particular concern in this proceeding is protection of RAS and EESS observations in the 1.4 GHz and 1.6 GHz bands. For RAS, the 21-centimeter line of neutral atomic hydrogen is an extremely important radio spectral line. More than ninety percent of the atoms in the universe are hydrogen, and most of those are in the ground state. As a result, the discovery and regular observations of this spectral line have revolutionized understanding of the structure of our galaxy and, indeed, the entire universe. Numerous and detailed studies of neutral hydrogen distribution in our own and other galaxies are being used to investigate the state of interstellar matter, the dynamics and distribution of interstellar gas, the rotation of our own and other galaxies, and the potential for star formation in other galaxies, as well as to estimate the masses of galaxies.

The expansion of the universe causes distant objects to move away from Earth at velocities that increase with distance. This motion causes a Doppler-effect shift of the radiation from neutral atomic hydrogen from its rest frequency (1420.406 MHz) to lower frequencies. The amount of frequency shift ("redshift") is an indicator of the distance to the emitting source, and, accordingly, analyses of such redshifts have provided distance measurements to thousands of galaxies, contributing significantly to our understanding of the structure of galaxy distribution and thus to the history of the universe. For example, redshifted hydrogen lines of distant galaxies extend down to the 1390-1395 MHz band under consideration in this NPRM.

The 1400-1427 MHz band is also heavily used by radio astronomers for continuum observations. Indeed, the *ITU Handbook on Radio Astronomy* (International Telecommunication Union, Geneva, 1995) lists the 1400-1427 MHz band as one of the preferred bands of the spectrum for continuum observations. (*Id.* at Section 3.2, Table 1.²) As noted in paragraph 20 of the NPRM, recognition of the importance of these continuum observations is reflected in Footnote US311.³ The adjacent bands above 1400-1427 MHz serve as a guard band and also provide increased bandwidth, which enables a slight increase in continuum sensitivity. In addition, the 1429-1432 MHz band is used to study highly redshifted hydroxyl (OH) spectra

² That table is reproduced from Table 3 of Recommendation ITU-R RA.314.8.

³ Paragraph 20 of the NPRM states that there are no current non-government operations in the 1390-1395 MHz band. CORF notes, however, that the Allen Telescope Array at Hat Creek, California, is currently being constructed. This facility is privately funded, with \$26 million in committed funding, and is being jointly developed by the University of California and the SETI Institute. The facility will have nearly 10,000 square meters of collecting area and will have continuous spectral coverage from 1-11 GHz. The facility will make possible many high-frequency-resolution measurements in the 1390-1395 MHz band.

(shifted down from ~1610 MHz) and the hexatriynyl radical (C_6H) line at 1429.5974 MHz. References to the “1.4 GHz band” in these comments thus include the 1390-1395 MHz band as well as the 1427-1435 MHz bands.

RAS research using observations in the 1.4 GHz band has been substantial from the beginning of radio astronomy, and observations in the band continue unabated. In the United States alone, observations are conducted at sites of the National Radio Astronomy Observatory (“NRAO”) at Green Bank, West Virginia, and Socorro, New Mexico; at the Very Long Baseline Array (“VLBA”) NRAO facility (10 RAS antennas distributed across the continental United States, Hawaii, and the Virgin Islands); and the observatory of the National Astronomy and Ionosphere Center (“NAIC”) at Arecibo, Puerto Rico. A large portion of RAS telescope time at these facilities⁴ is spent on observations in this band, and this percentage of use is expected to continue.

The 1400-1427 MHz band is the primary band for EESS observations below 6 GHz and is essential for measurement of soil moisture using spaceborne remote sensors. It is the only band allocated for EESS that can be used for this application. An extensive empirical database has been assembled over the past 30 years to characterize the natural microwave emission responses of soil moisture, composition, and roughness and of agricultural and natural vegetation canopies specifically in this frequency band because of its protected status. Soil moisture measurements are important for assessment of the health of crops and for drought and flood monitoring, all of which affect the welfare of the human population. Measurement of soil moisture by spaceborne passive sensors holds the promise of providing global synoptic soil moisture data that cannot be obtained feasibly by any other means.

Satellite remote sensing in this band is also important for measuring ocean salinity. A series of exhaustive laboratory and satellite studies of the ocean’s dielectric properties have been conducted over the past several decades with particular emphasis on their behavior in the 1400-1427 MHz band. Global imaging of ocean salinity will have an enormous impact on our ability to forecast and model global climate because of ocean salinity’s role in surface buoyancy and air/sea latent heat flux. In both the land and ocean cases, the response of the natural microwave emission to the variables of interest rapidly diminishes above the 1400-1427 MHz band. This behavior, combined with the increased likelihood of interference below the band and the extensive body of knowledge assembled in the band, make the 1400-1427 MHz band a unique and necessary frequency range for these EESS observations.

⁴ Observations are also made at the Dominion Radio Astrophysical Observatory at Penticton, British Columbia, Canada, as well as other observatories throughout the world.

CORF is pleased that the NPRM recognizes the importance of protecting “extremely sensitive radio astronomy receivers in the...1660-1670 MHz band, as well as the need to protect meteorological-satellite Earth stations at the Wallop’s Island and Fairbanks sites.” (NPRM at para. 39.) It should be noted that there are exclusive primary and co-primary allocations to the RAS in the 1660-1660.5, 1660.5-1668.4, and 1668.4-1670 MHz bands. There is a reason for these primary allocations: observations in and around these frequency bands are among the most important for the science of radio astronomy, for both continuum and spectral line observations of hydrogen and the hydroxyl (OH) radical. Such observations are of great importance to scientists studying stellar expansion velocities and the origins and evolution of the universe. The *ITU Handbook on Radio Astronomy* lists the 1660-1670 MHz band as one of the preferred bands of the spectrum for continuum observations. (*Id.* at Section 3.2, Table 1.) In addition, the *Handbook* includes the OH spectral lines with rest frequencies of 1665.402 and 1667.359 MHz as being among those of greatest importance to radio astronomy. (*Id.* at Section 3.3, Table 2.)

In sum, the 1.4 GHz and 1.6 GHz bands at issue in this proceeding are important for scientific observations and research, yet like all passive scientific observations, are uniquely vulnerable to interference from out-of-band and spurious emissions. Accordingly, obtaining allocations in the nearby bands that would be “good neighbors” (unlikely to cause interference to passive scientific observations) makes good sense: such allocations promote spectrum efficiency by allowing for multiple uses, while minimizing the likelihood of interfering with scientific research.

II. CORF Opposes 1.4 GHz Band Plan Option 3, and Any Allocation of Airborne, Satellite Uplink, or Satellite Downlink Services in the 1.4 GHz Band

Given the tremendous importance of the 1.4 GHz band at issue herein to both the RAS and the EESS, as described above, CORF strongly opposes 1.4 GHz Band Plan Option 3, as well as any allocation of airborne, satellite uplink, or satellite downlink services as part of the other Options. Such uses in bands neighboring RAS or EESS bands pose a substantial threat of harmful interference to passive scientific observation. In para. 33 of the NPRM, the Commission notes that Resolution 127 adopted at WRC-2000 recognizes the dangers of Little LEO (small, low-Earth-orbit communications satellites) downlinks in these bands to RAS observations, but also suggests that various techniques “may” mitigate the harmful impact to acceptable levels. This suggestion provides no rational or practical basis for enacting the Little LEO provisions of Option 3. The issue of harmful interference from Little LEO downlinks in this band is currently

being studied by the ITU, and *no conclusions* have been reached yet to support the assertions of Little LEO companies. Furthermore, because this issue may be addressed at WRC-2003 or WRC-2006, Commission allocations to Little LEOs as a result of this proceeding would prejudice and preempt the future ITU studies and actions. This is not sound spectrum policy, and the Commission should not make Little LEO allocations in this band at this time.

Allocations for other satellite uplinks or downlinks, or for aeronautical uses, as part of the other Options have even less basis than do Little LEO proposals. And, as the NTIA recognizes, such uses are inconsistent with protection of operations in neighboring bands. (NPRM at para. 28 and note 67.)

Interference to EESS passive sensors from satellite uplinks in this band is particularly harmful because spaceborne sensors view Earth, and the satellite uplink transmissions can be coupled directly into the high-gain antennas and the ultra-sensitive receivers of passive sensors. CORF believes that uplink transmissions must be prohibited above 1392 MHz in order for satisfactory operation of passive sensors in the 1400-1427 MHz band. In addition, suitable limits must be adopted for uplink transmission power levels if they are to take place in the 1390-1392 MHz band, and out-of-band filtering requirements must be imposed if levels of interference in the 1400-1427 MHz band are to be kept below the interference criteria for the sensors. Specific values of power limits and filter specifications are expected to be available from studies conducted by ITU-R Working Party 7C.

III. CORF Does Not Oppose Allocation of the 1670-1675 MHz Band to Fixed and Non-Aeronautical Mobile Services, Subject to Significant Protections in Service Rules

As is noted in Section I above, passive scientific observations in the 1.6 GHz band are important, yet vulnerable to interference. The NPRM recognizes these concerns and seeks comments on appropriate power limits and license areas. CORF concurs with this approach and does not oppose the allocation of the 1670-1675 MHz band to Fixed and Mobile Services (except aeronautical mobile), as long as service rules are enacted that protect important RAS observations in the 1660-1670 MHz band. CORF strongly supports the Commission's proposal (NPRM at para. 39) to prohibit airborne or space-to-Earth applications.

In regard to fixed services, CORF recommends the use of mandatory coordination procedures similar to those already enacted in Sections 1.924(a) and 1.924(d) of the Rules. While protection of the NRAO Green Bank and Arecibo observatories could be accomplished by merely

making fixed licensees in the 1670-1675 MHz band explicitly subject to Sections 1.924(a) and 1.924(d), this approach would not suffice for protection of other important observatories. Accordingly, the Commission should enact a new Section in its rules (perhaps as a new part of Section 1.924) providing for coordination procedures for applications proposing fixed uses in this band within 160 kilometers of the VLA and within 100 kilometers of the VLBA sites, as described in US311. (Cf. Section 25.213(a)(1) of the Rules.) The new Allen Telescope Array (located at 40 deg 49 min north latitude and 121 deg 28 min west longitude) at Hat Creek, California, could be protected by using the existing coordination area specified in US256 for the 1.7 GHz band.

In any case, to ensure protection of passive users, it is critical that the above protections be specifically enacted in this proceeding, rather than putting off such matters for another proceeding on service rules. Addressing these same issues in this proceeding and in a subsequent proceeding on service rules would be wasteful of Commission and private resources, would cast uncertainty on the uses of the new services, and could lead to harmful interference, if in a later proceeding, commenters were to attempt to suggest reasons that the interference concerns recognized at the time of this proceeding had subsequently become less important.

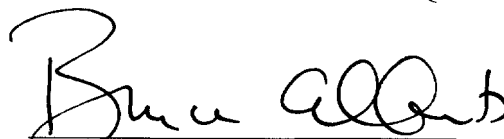
IV. Conclusion

CORF strongly opposes the 1.4 GHz Band Plan Option 3 because both experience and calculations indicate that the allocations proposed therein will be harmful to users of the EESS and RAS who make observations in the 1.4 GHz band. In addition, CORF does not oppose the allocation of the 1670-1675 MHz band to Fixed and Mobile Services (except aeronautical mobile), as long as service rules suggested herein are enacted that protect important RAS observations in the adjacent 1660-1670 MHz band.

Respectfully submitted,

NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

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February 16, 2001

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